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COMPLETE SPECIFICATION

Suspension Polymerization and Apparatus therefor

We, UNION CARBIDE CORPORATION, a corporation organized under the Laws of the State of New York, United States of America, of 270, Park Avenue, New York, 17, State of New York, United States of America, to hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process and apparatus for polymerising vinyl compounds. More particularly, the invention relates to a process and tower reactor for the continuous production of vinyl polymers by suspension polymerization.

It is well known that various polymerization processes have been developed for the production of numerous homopolymers and copolymers from vinyl compounds such as vinyl chloride, vinyl acetate, vinylidene chloride, octyl acrylate, styrene or isobutylene. For many commercial purposes the spherical polymer bead obtained by suspension polymerization is preferred over the polymer resulting from an emulsion polymerization since there are distinct and characteristic differences in particle size of the polymer produced. For example, in a suspension polymerization, a monomer or mixture of monomers is dispersed into droplets suspended in a second liquid phase in which both monomer and polymer are essentially insoluble. The monomer droplets, which are larger than those in a true emulsion, are then polymerized while dispersion is maintained by continuous agitation to produce a substantially uniform spherical polymer bead which has a particle diameter ranging from 10 to 200 microns. On the other hand, emulsion polymerization, which depends upon the solubilization of the monomers to

form an emulsion and differs from suspension polymerization in that polymerization does not take place in the droplets of monomers but rather in newly formed monomer-polymer particles which arise in an aqueous phase surrounding the droplets, produces a polymer of higher molecular weight which has a particle diameter of about one micron. Although the polymerization by suspension provides a spherical resin bead having a desirable uniform particle size, the use of this polymerization technique has been handicapped to a large extent by the fact that up to now commercial processes for the producing of vinyl resins by suspension polymerization have been restricted to batch systems. This is because it has been impossible to prevent over-conversion and growth of the resin particles in a system where complete recirculation of the reaction slurry is present. This causes particles to grow due to contact with fresh monomer and many of the monomers become over-converted due to excessive retention time in the system.

According to the present invention there is provided a method for the continuous suspension polymerization of a charge stock comprising a polymerizable vinyl compound, polymerization catalyst, suspending agent and a liquid suspending medium in which the vinyl compound has a lower density than the suspending medium and the polymer thereof has a higher density than the suspending medium, which method comprises continually introducing the charge stock in liquid phase into the upper end of a vertically disposed elongated polymerization zone which communicates at its lower end with a settling zone, dispersing the vinyl compound into droplets in the liquid medium to form a suspension, heating the suspension

to polymerize the vinyl compound, passing the vinyl compound as its density increases by polymerization downward by turbulent transfer and free settling through a series of superposed mechanically agitated conversion zones formed in that portion of the polymerization zone between the charge inlet and settling zones, each of said conversion zones being of increasing vertical thickness, wherein the vinyl compound, as its density increases, is at a fixed density and conversion in a given conversion zone, continuously withdrawing from the settling zone a slurry containing vinyl polymer, unpolymerized vinyl compound and water at a rate related to the incoming charge stock, and recovering from the slurry the finished polymer.

The present invention provides a continuous suspension polymerization for the preparation of vinyl polymers and copolymers by the method which comprises continually introducing in liquid phase into the upper end of a reaction chamber, a charge stock containing a polymerizable vinyl compound, polymerization catalyst, suspending agent and liquid suspending medium, and continuously removing from a settling zone which communicates with the reaction chamber at its lower end a slurry containing vinyl polymer, unpolymerized vinyl compound and suspension medium. The reaction chamber comprises a vertically disposed pressure reactor of large height to diameter ratio and the contents of the reactor are agitated by three or more radial-flow impeller units attached to a single rotatable agitator shaft disposed within the reactor in vertical position. The impeller units disperse the vinyl compound into droplets in the suspending medium to form a suspension, and are attached at increasingly spaced intervals from the top of the agitator shaft toward the bottom in order to provide a series of mechanically agitated superposed conversion zones through which globules of vinyl monomer migrate as their particle density increases with polymerization.

The design of the tower reactor is based on the principle of controlled settling which permits a variable retention time of individual monomer particles so that the particles are removed from the reactor at the desired degree of conversion. The theory of the agitation effected by increasingly spaced impeller units is to supply the minimum amount of agitation to mechanically shear the monomer into the desired size droplets and to maintain a suspension. The amount of agitation required to maintain a suspension decreases as the density of the dispersed phase approaches the density of the suspending medium. Therefore the distance between impellers is increased down through the reactor. This reduces the recirculation of particles, which results in overconversion and particle growth

and produces a polymer product of uniform conversion. 65

As compared to batch systems of suspension polymerization wherein the average conversion of monomer particles is the control point, and a uniform conversion necessitates having the same temperature and catalyst concentration inside each droplet of monomer, the continuous process of this invention provides a more uniform polymer product having less variation in molecular weight, chemical composition, particle size and distribution. 70 75

Referring now to Figure 1, of the accompanying drawing, the preferred form of the polymerization apparatus comprises a relatively tall vertical pressure vessel or tower reactor 10 consisting of a shell member 12, preferably of cylindrical shape, having a height of at least four times its diameter. The ratio of height to diameter of the reactor may vary widely between the limits or from 4 to 60 and is preferably between from 6 to 15. The vertical sides of reactor 10 may be surrounded by a temperature control means consisting of a reactor jacket 13 which is provided with one or more conduit means 14 through which heating or cooling fluids or gases may be circulated. The temperature in the system is kept constant by any of the suitable automatic controls well known to those skilled in the art. In the examples set forth hereinafter the temperature in the system was maintained between 50° C. and 75° C. during the polymerization. 80 85 90 95

The tower reactor is provided with an upper closure member 15 and a lower closure member 16. Each closure member 15 and 16 consists of a plate member which is sealed to the shell member 12 and reactor jacket 13 by any suitable means, as by welding, for example, so as to provide a completely waterproof seal. Passing centrally through the top of closure member 15 is a vertical agitator shaft 18 to which three or more impeller units 20 are attached at increasingly spaced intervals. Each impeller unit consists of two or more vertical impeller blades 21 which are secured in a radial position, each blade being from 3 to 7 inches long and from 1 to 5 inches wide. The outside diameter from tip to tip of the impeller blades expressed at a ratio of reactor diameter to impeller diameter is from 1.5 to 5, and preferably from 1.5 to 3. The impellers impart radial flow to the liquid in the reactor and are to be distinguished from the propellers of the prior art which impart vertical flow to a liquid. 100 105 110 115 120

The shaft 18 is centrally supported in a steady bearing structure 19 attached to lower closure member 16 and extends vertically therefrom passing through a bearing closure structure 19 located in the upper closure member 15. The shaft 18 is driven by a power source M which is preferably 125

an electric motor. The power source may also consist of other suitable means such as a pulley and belt drive, or a power driven gear box.

5 Located adjacent the top closure member 15 are separate feed conduits 8 and 9. The upper conduit 8 serves as an inlet for the feed stream comprising monomers, catalyst and any organic diluent which may be employed, while the suspending medium and suspending agents are introduced through the lower conduit 9. Although the separate feed streams which are illustrated are desirable for economical considerations, the entire feed stream may, if desired, be introduced through a single conduit.

10 The lower portion 23 of the reactor 10 serves at a settling and separation zone and an outlet conduit or discharge pipe 24 is connected to the bottom closure member or to an adjacent portion thereof so as to permit withdrawal of the reaction slurry. The outlet 24 may be provided with a suitable closure valve.

25 While the bottom portion of the reaction vessel 10 is shown as being flat, it is not essential for operation of the tower that the construction be of this design. The bottom portion may be conical or dish shaped and in many instances a conical bottom is preferred since it facilitates product removal.

30 Disposed on the interior wall of the reactor vessel and extending away therefrom are one or more vertical baffles 11 or other similar constructions which are from 1/10 to 1/12 of the reactor diameter in width. The baffles are located about 90 degrees apart and serve to increase frictional resistance of the feed slurry in the reaction vessel. The baffles are not essential for operation of the reactor but are desirable for eliminating stratification in the polymerization unit so as to provide a more uniform concentration and distribution of the organics in the mixed phase.

45 The tower reactor may be of glass-lined construction but is preferably of stainless steel.

50 As previously mentioned, the continuous suspension polymerization of vinyl monomers is based on the principle of controlled settling which permits a variable retention time of individual particles; that is, the particles are removed from the reactor when and only when they reach a given degree of conversion.

55 To accomplish the desired conversion the tower reactor 10 contains a plurality of superposed conversion zones 30, 31 and 32 provided by means of the impellers 20 attached to the shaft 18 at increasingly spaced intervals between the feed inlets 8 and 9 and settling zone 23 wherein monomer particles in a given zone are at a fixed density and conversion, and are free to move downward from one zone to another as their density or conversion changes. For example, the monomer drop-

let or vinyl chloride increases in density from 0.9 to 1.4 during polymerization. When the monomer is dispersed in the suspending medium at the top tower 10 the suspended particles are moved downward as polymerization occurs, dropping from one conversion zone to the next, until finally the finished polymer particles are withdrawn as a slurry from the bottom of the tower through conduit 24, and are subsequently recovered. The impeller units provide a heterogeneous agitation system of separate conversion zones and the monomer droplets, as polymerization is effected, are moved downward through each zone 30, 31 and 32 to the settling zone 23 by turbulent transfer and free settling. Since the monomer particles grow in density as they polymerize, and thus reach a point where their density is greater than the suspending medium, the suspension medium together with a solid polymer of several hundred monomer units can be continuously withdrawn from the reaction vessel at a rate related to the incoming feed material, which is maintained in the reaction vessel at a constant level, so as to provide a continuous method of suspension polymerization.

The spacing between impeller units may increase gradually or stepwise, and under particular circumstances it may be desirable to arrange the impellers in clusters along the shaft. The essential feature, however, is that the average distance between impellers increases from the upper part of the shaft toward its lower part. The impeller spacings are empirical and to determine the spacing for various polymerization systems a method was employed which involved the following procedure. Solid particles were dispersed in water in a glass column with impellers at different speeds. The distance the dispersed particles were formed below the impeller was observed and this information was then plotted with the particle density as the parameter on an impeller influence versus impeller speed graph. In determining the impeller spacings for a tower, the agitation speed was set based on a rough knowledge of the particle size-speed relationship for a fixed polymer recipe. Also an arbitrary particle density was set for each conversion zone; for example, a particle density of 0.85 to 0.90 was set for the first zone, and a density of 0.91 to 0.95 for the second zone, etc. After restricting the system on speed and density, the plotted data were applied so that 0.90 density particles would not be forced down into the next zone but that 0.91 density particles would be forced down. This procedure was followed for each zone until the monomer particles reached a given degree of conversion and were present in one zone as finished polymer particles.

Based on the above procedure, and as applied to polymers systems contemplated

herein, the distance between the top impeller unit and the one below it should be between from 0.5 impeller diameters and 6 diameters, preferably from 1 to 3 impeller diameters, based on the outside diameter of the impeller blades. Generally, at a distance from the top impeller unit of about 30 per cent of the length of the shaft, the impeller spacing will be greater than the spacing between the first two impeller units by a distance of from 0.5 up to 1.5 impeller diameters. At a distance from the top impeller unit of about 60 per cent of the length of the shaft, the spacing between impellers should be greater than the spacing between the first two by from 1 to 3 impeller diameters.

The number of impeller units which may be employed on the shaft in the tower reactor, based on a ratio of reactor height to reactor diameter between from 4 to 60, as previously described, ranges from 3 to 50 units which provides a maximum 50/50 monomer to water ratio in any one conversion zone so as to prevent phase inversion. The preferred number of impeller units varies between from 6 and 20. If a given number of impeller units are required to handle satisfactorily a polymerization system which produces a polymer of density D , only 60 per cent of that number of impeller units will be required to handle satisfactorily a system which is otherwise identical but which produces a polymer of density $D+0.100$.

Each impeller unit may contain from two to eight or more blades, preferably of rectangular shape, which may be canted in the plane of rotation. It is preferred to employ a three or four-bladed impeller since increased numbers of impeller blades apparently produce no observable improvement on the agitation system other than to provide a more even interface between the mixed phase and water phase.

The impeller or agitator speed, stated in terms of linear peripheral velocity of the tip ranges from 100 to 600 feet per minute, and is preferably from 150 to 350 feet per minute.

In operation of the apparatus the suspension polymerization ingredients are fed into the top of the reactor preferably through the separate feed lines 8 and 9 by controlled volume pumps. The monomer feed stream contains the monomer or mixture of monomers, catalyst, and any organic diluent employed, while the suspending medium, which is usually water, contains the suspending agent and any wetting agent employed. The normal operating procedure is to fill the reactor with the suspending medium, adjust the temperature, pressure and impeller speed, and then feed both the monomer and suspension streams at the desired rates. The temperature of the polymerization is automatically controlled by passing hot water through the reactor jacket from bottom to top and will

vary from 25° C. up to the boiling point of the monomers. The reactor is preferably operated full of liquid to reduce polymer build up on the reactor at liquid level. A slurry containing the finished polymer, unpolymerized monomer and water is continuously withdrawn from the reactor through conduit 24. Unreacted monomer is removed from the slurry by vaporization and the finished polymer is recovered by filtration and drying. Generally, depending upon the type of polymer, the drying operation is carried out at a temperature of from 50° to 70° C. to remove most of the water and the polymer is finished drying to a 98 per cent or more total solids content in an elutriator type dryer with nitrogen.

The pressure employed in the process should be sufficient to maintain the feed materials in the liquid state under the temperature of polymerization.

The rate at which the feed streams are admitted to the reaction vessel during the polymerisation is subject to considerable variation. The feed rate may be determined as a function of the polymerization of the monomer which, in turn, is a function of the catalyst concentration, reaction temperature, and reaction rate of the particular monomer polymerized.

The continuous suspension polymerization of this invention is applicable to a wide variety of vinyl compounds. The requirements as to the types of polymers which may be produced are as follows: the monomer must have a lower density than the suspending medium; the polymer must have a higher density than the suspending medium; and for copolymers requiring a narrow range in chemical composition, the monomers must have about equal reactivities. Among the vinyl compounds which may be polymerized or copolymerized are vinyl chloride, vinyl acetate, octyl acrylate, vinylidene chloride, vinyl butyrate, vinyl acrylate, styrene, acrylonitrile, and isobutylene.

Preferred polymers which may be prepared and which are of particular interest because of their good flow properties, particle porosity, and particle size, comprise polyvinyl chloride, polyvinyl acetate, and vinyl chloride-octyl acrylate and vinyl chloride-vinyl acetate copolymers. These resins which are produced by the tower suspension process have less fines and course materials than those produced by a batch process. Practically all of the resins particles produced are spherical in shape and range in particle diameter from 10 to 200 microns.

The catalysts used for the suspension polymerization may be any of the polymerization catalysts that are known for this purpose, such as hydrogen peroxide, persulphuric acid, peracetic acid, benzoyl peroxide, dilauroyl peroxide, barium peroxide, calcium peroxide and

the persalts such as the percarbonates, perborates or perphosphates. The catalyst must be soluble in the monomer or mixture of monomers. The amount of catalyst to be employed will vary from 0.01% up to 5.0%, and preferably from 0.1% up to 2.0%, based on the monomer phase.

The suspending agents that may be used in the process include methyl cellulose, carboxymethyl cellulose and polyvinyl alcohol. Wetting agents are frequently desirable in the suspension polymerization and for this purpose suitable materials include salts of the higher alkali metal alkyl sulphates such as sodium and/or potassium lauryl sulphate, the salts of alkyl naphthalene sulphonic acids such as sodium isopropyl naphthalene sulphonate, and the alkylene sulphonates such as cetyl sulphonates, oleyl sulphonates and stearyl sulphonate.

Following is a description by way of example of methods of carrying the invention into effect.

EXAMPLE 1.

An eight-inch diameter by thirty-foot tall jacketed reactor was used to prepare a polyvinyl chloride resin continuously by a suspension process. The contents of the reactor were stirred by 15 four-inch diameter, turbine, radial flow impeller units on a top-entering centered-mounted shaft. The distance between each of the first seven impeller units was 3 impeller diameters; followed by 3 four and one-half impeller diameter spaces; the distance between the rest of the impeller units was 6 impeller diameters each. The impellers had 3 one-inch by two-inch flat blades.

Seventy-five pounds per hour of a mixture containing 8 parts water, 2 parts vinyl chloride, 0.01 parts dilauryl peroxide, and 0.005 parts polyvinyl alcohol was fed to the reactor continuously over a period of 34 hours. The reactor was maintained at a temperature of 53° C. and a pressure of 140 psig. The impellers were operated at a peripheral speed of 3.5 feet per second.

Sixty per cent of the vinyl chloride was converted to polymer in the reactor. A slurry containing the polymer, unpolymerized vinyl chloride, and water was continuously removed from the bottom of the reactor. The resin was recovered from the slurry by filtration and drying. The dried resin had a median particle diameter of 73 microns, specific viscosity of a 0.2% nitrobenzene solution of 0.185, and a loose bulk density of 31 pounds per cubic foot.

EXAMPLE 2.

A two-foot diameter by thirty-foot tall jacketed reactor was used to prepare a polyvinyl chloride resin continuously by a suspension process. The contents of the reactor were stirred by 9 ten-inch diameter turbine impellers on a top-entering, center-mounted

shaft. The distance between each of the first four impeller units was 1.8 impeller diameters; followed by three spaces 2.5 impeller diameters each. The last three impeller units were spaced 3.5 impeller diameters apart. The remaining portion of the tower was used as a settling zone.

Seven hundred fifty pounds per hour of a mixture containing 8 parts water, 2 parts vinyl chloride, 0.01 parts of dilauryl peroxide, and 0.0095 parts polyvinyl alcohol was fed to the reactor for 27 hours. The reactor was maintained at a temperature of 54° C. and a pressure of 135 psig. The impellers were operated at a peripheral speed of 3.9 feet per second.

Sixty-five per cent of the vinyl chloride was converted to polymer in the reactor. A slurry containing the polymer, unpolymerized vinyl chloride and water was continuously removed from the bottom of the reactor. The resin was recovered from the slurry by filtration and drying. The dried resin had a median particle diameter of 76 microns, specific viscosity of a 0.2% nitrobenzene solution of 0.181, and a loose bulk density of 28 pounds per cubic foot. The resin from this run had a very narrow molecular weight range as illustrated by less than 1% variation in specific viscosity of a number of spot samples obtained during the run.

EXAMPLE 3.

A five-foot diameter by thirty-two foot tall jacketed reactor was used to prepare a polyvinyl chloride resin continuously by a suspension process. The contents of the reactor was stirred by 5 two-foot diameter turbine four-bladed impellers. The distance between the impeller units was 1.25, 1.75, 2.25 and 2.75 diameters, respectively. The bottom portion of the reactor was used as a settling and separation zone.

Four thousand pounds per hour of a mixture containing 7 parts water, 3 parts vinyl chloride, 0.15 parts dilauryl peroxide, and 0.01 parts of polyvinyl alcohol was fed to the reactor continuously for 62 hours. The reactor was maintained at a temperature of 55° C. and a pressure of 140 psig. The impellers were operated at a peripheral speed of 5.2 feet per second. Forty-five percent of the vinyl chloride was converted to polymer in the reactor. A slurry containing the polymer, unpolymerized vinyl chloride, and water continuously removed from the bottom of the reactor. The unpolymerized vinyl chloride was separated from the water and monomer by vaporizing. The resin was recovered from the water by filtration and drying. The dried resin had a median particle diameter of 120 microns, specific viscosity of 0.175, and a loose bulk density of 24 pounds per cubic foot.

EXAMPLE 4.

The equipment described in Example 3 was

used to prepare a sample of low molecular weight polyvinyl chloride resin continuously by a suspension process.

Four thousand pounds per hour of a mixture containing 7 parts water, 3 parts vinyl chloride, 0.009 parts dilauroyl peroxide, and 0.006 parts polyvinyl alcohol was fed to the reactor. The reactor was maintained at a temperature of 72° C. and a pressure of 175 psig. The impellers were operated at a peripheral speed of 5.5 feet per second.

Approximately eighty per cent of the vinyl chloride fed to the reactor was converted to polymer. A slurry containing the polymer, unpolymerized vinyl chloride, and water was continuously removed from the bottom of the reactor. The unpolymerized vinyl chloride was removed from the slurry by vaporization. The resin was recovered by filtration and drying. The dried resin was a fine, uniform, free-flowing material with a median particle diameter of 90 microns, a specific viscosity of 0.117, and a loose bulk density of 36 pounds per cubic foot.

EXAMPLE 5.

The equipment described in Example 1 was used to prepare a vinyl chloride-vinyl acetate copolymer resin continuously by a suspension process.

Seventy-five pounds per hour of a mixture containing 8 parts water, 1.6 parts vinyl chloride, 0.4 parts vinyl acetate, 0.0015 parts dialauroyl peroxide, and 0.004 parts polyvinyl alcohol was fed to the reactor continuously for a period of 35 hours. The reactor was maintained at a temperature of 72° C. and a pressure of 168 psig. The impellers were operated at a peripheral speed of 3.4 feet per second.

Seventy-five per cent of the monomer was converted to polymer in the reactor. The slurry from the reactor containing polymer, unpolymerized monomer, and water was continuously removed from the bottom of the reactor. The unpolymerized monomers were removed by vaporization and the polymer was recovered from the water by filtration and drying. The dried resin was free-flowing and contained uniform, spherical, dense particles with a median diameter of 92 microns, a specific viscosity of 0.102, and a polyvinyl chloride content of 85%, with a loose bulk density of 43 pounds per cubic foot.

EXAMPLE 6.

The equipment described in Example 1 was used to prepare a polyvinyl acetate resin continuously by a suspension process.

Thirty-five pounds per hour of a mixture containing 7 parts water, 3 parts vinyl chloride, 0.009 parts dilauroyl peroxide, and 0.0021 parts polyvinyl alcohol was fed to the reactor. The reactor was maintained at a temperature of 70° C. and a pressure of 150 psig. The impellers were operated at a peripheral speed of 3.0 feet per second.

A slurry containing the polymer, unpolymerized monomer, and water was continuously removed from the bottom of the reactor. Essentially all of the monomer was converted to polymer in the reactor. The resin was recovered from the slurry by filtration and drying. The dried resin had a median particle diameter of 80 microns. A molar solution of the polymer in benzene gave a viscosity of 300 centipoises (8.66 grams of polymer per 100 cc benzene solution).

EXAMPLE 7.

The equipment described in Example 1 was used to prepare a copolymer of vinyl chloride and octyl acrylate continuously by a suspension process.

Seventy-five pounds per hour of a mixture containing 7 parts water, 2.6 parts vinyl chloride, 0.4 parts octyl acrylate, 0.012 parts dilauroyl peroxide, and 0.0035 parts of polyvinyl alcohol was fed to the reactor for 20 hours. The reactor was maintained at 50° C. and a pressure of 100 psig. The impellers were operated at a peripheral speed of 3.0 feet per second.

A slurry containing polymer, unpolymerized monomer, and water was continuously removed from the bottom of the reactor. The resin was recovered by vaporizing the unreacted monomers and filtering and drying. The dried resin consisted of fine, free-flowing, spherical particles with a median diameter of 80 microns, specific viscosity of 0.205, and a polyvinyl chloride content of 79 per cent.

WHAT WE CLAIM IS:—

1. A method for the continuous suspension polymerization of a charge stock comprising a polymerizable vinyl compound, polymerization catalyst, suspending agent and a liquid suspending medium in which the vinyl compound has a lower density than the suspending medium and the polymer thereof has a higher density than the suspending medium, which method comprises continually introducing the charge stock in liquid phase into the upper end of a vertically disposed elongated polymerization zone which communicates at its lower end with a settling zone, dispersing the vinyl compound into droplets in the liquid medium to form a suspension, heating the suspension to polymerize the vinyl compound, passing the vinyl compound as its density increases by polymerization downward by turbulent transfer and free settling through a series of superposed mechanically agitated conversion zones formed in that portion of the polymerization zone between the charge inlet and settling zones, each of said conversion zones being of increasing vertical thickness, wherein the vinyl compound, as its density increases, is at a fixed density and conversion in a given conversion zone, continuously withdrawing from the settling zone a slurry containing vinyl polymer, unpolymerized vinyl compound and water at a rate

- related to the incoming charge stock, and recovering from the slurry the finished polymer.
2. A method as claimed in Claim 1, in which the polymerizable vinyl compound is vinyl chloride, vinyl acetate or octyl acrylate.
3. A method as claimed in Claim 1 or Claim 2 in which the finished polymer has a particle diameter of from 100 to 200 microns.
4. A method for the continuous suspension polymerization of vinyl compounds substantially as described with reference to the specific examples hereinbefore set forth.
5. An apparatus for the continuous suspension polymerization of vinyl compounds according to Claim 1, which comprises a vertically disposed elongated chamber having a height to diameter ratio of from 4 to 60, a closure member secured to each end of the chamber, a rotatable agitator shaft disposed within the chamber in vertical position, means for rotating the shaft, and a plurality of impeller units attached to the shaft which the spacing between the impeller units increases in distance from the upper part of the shaft to the lower portion thereof, said impeller units providing a series of superposed mechanically agitated conversion zones.
6. An apparatus as claimed in Claim 5, in which the chamber height to diameter ratio is from 6 to 15.
7. An apparatus as claimed in Claim 5 or Claim 6, in which from 3 to 50 impeller units are attached to the shaft.
8. An apparatus as claimed in Claim 7, in which from 6 to 20 impeller units are attached to the shaft.
9. An apparatus as claimed in any one of Claims 5 to 8, in which the spacing between the first and second uppermost impeller units is between 0.5 and 6 impeller diameters, based on the outside diameter of the impeller blades, the spacing between impeller units at a distance of 30 per cent of the length of the shaft from the first impeller unit is greater than the spacing between the first and second impeller units by a distance of 0.5 to 1.5 impeller diameters, and the spacing between impeller units at a distance of 60 per cent of the length of said shaft from the first impeller unit is greater than the spacing between the first and second impeller units by a distance of 1 to 3 impeller diameters.
10. An apparatus as claimed in Claim 9, in which the spacing between the first and second uppermost impeller units is between 1 and 3 impeller diameters, based on the outside diameter of the impeller blades.
11. An apparatus for the continuous suspension polymerization of vinyl compounds according to Claim 1 substantially as hereinbefore described and with reference to the accompanying drawing.

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COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of
the Original on a reduced scale

